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Effect of transplanting date and age of seedlings on growth, yield and quality of hybrids under system of rice (*Oryza sativa*) intensification and their effect on soil fertility

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ABSTRACT

A field experiment to study the effect of transplanting date and age of seedlings on growth, yield and quality of rice hybrids under SRI and their effect on soil fertility was conducted on sandy-clay loam soil at Varanasi during rainy (*kharif*) seasons of 2012 and 2013. The experiment on sandy loam soil was laid out in split-split plot design assigning three dates of transplanting (27 June, 7 July and 17 July) in main plot, two rice hybrids (PHB-71 and Pusa RH-10) in sub-plot and three age of seedlings (10, 14 and 18-day old) in sub-sub plot with three replications. Results revealed that higher growth parameters, viz. plant height (104.2 cm), tillers/hill (20.4), leaf area index (5.16) and dry matter accumulation/hill (31.2 g) and yield attributes, viz. effective tillers/m^2 (248.2), panicle length (30.5 cm), grains/panicle (176), weight/panicle (5.08 g) and test weight (23.11 g), grain and straw yield (6.67 and 8.71 tonnes/ha, respectively) and harvest index (43.17) were observed under 27 June transplanting as compared to rest of the two dates of planting. Protein content in grain and kernel length before and after cooking also registered significant improvement in 27 June transplanted crop. The magnitude of increase in grain and straw yield of hybrid under SRI by the early transplanting (27 June) as compared to the late transplanting (17 July) was 19.9 and 15.2 %, respectively on pooled basis. However, soil pH, EC, organic carbon, available NPK, hulling, milling and head rice recovery percentage, kernel breadth (B) before and after cooking, length (L) elongation ratio and L/B ratio remained unaffected due to different dates of transplanting. Among the hybrids, PHB-71 produced markedly higher plant height (104.8 cm), tillers/hill (17.6), leaf-area index (4.91), dry matter accumulation/hill (29.5 g), effective tillers/m^2 (236.4), panicle length (30.1 cm), grains/panicle (188), weight/panicle (4.62 g), test weight (22.67 g), grain yield (7.00 tonnes/ha), straw yield (8.95 tonnes/ha) and harvest index (43.87) over Pusa RH-10. Organic carbon content in soil as well as quality parameters viz. hulling, milling and head rice recovery percentage, protein content and kernel breadth before and after cooking were also recorded higher with PHB-71 than the Pusa RH-10. However, maximum available NPK, kernel length before and after cooking, length elongation and length breadth ratio before cooking were recorded with 'Pusa RH-10'. Younger aged seedlings (10-day old) recorded significantly higher growth and yield parameters, yields and harvest index over older aged seedlings (18-day), whereas maximum available NPK was recorded with older aged seedlings (18-day). The 10-day old seedlings gave 6.4 and 12.9% more grain yield than 14 and 18-day old seedlings, respectively. Interactive effect on grain yield was significant among date of transplanting, age of seedlings and hybrids. Transplanting of PHB-71 hybrid on 27 June having either 10 or 14-day old seedlings resulted in markedly higher grain yield as compared to rest of the treatments.

Key words: Age of seedlings, Available NPK, Date of transplanting, Hybrids, Organic carbon, Quality parameters, SRI

India will need to produce more rice if it has to meet the growing demand which is, likely to be 130 million tonnes of milled rice in 2030. India ranks first in acreage (43.50 m ha), second in production (159.20 million tonnes) after China and average productivity of rice is 3 659.77 kg/ha (FAO, 2014). Rice provides 35–60% of the dietary calories and 50-80% of the energy intake of the people in developing countries (Fageria and Baligar 2003). India needs to produce 1.7 million tonnes of additional rice every year to ensure national food security (Dass and Chandra 2013), and the increased production should come from optimum time of transplanting, use of hybrids and younger age of seedlings to utilize phyllochronic potential for achieving higher yield.

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Rice cultivation in India is predominantly practiced by transplanting method that involves raising, uprooting and transplanting of seedlings. This is rather a resource and cost intensive method since preparation of seedbed, raisings of seedling and transplanting are labour and time intensive operations. To avoid these difficulties and fulfil the demand of increasing population of India, there is an urgent need to adopt some innovative techniques to break the yield ceiling in rice. The introduction of System of Rice Intensification (SRI) is gaining attention among the rice growers. The most obvious advantage from SRI appears to the yield increases in farmers' field without addition of extra seeds or chemical and mechanical inputs (Stoop *et al*. 2002). Beside the SRI, most important criterion is selection of hybrids for particular climatic conditions that performed well and produce significantly higher yield. It is one of the viable and proven technology available at present to enhance the rice productivity and production in the country (Yuan 2002). Performance of a genotype entirely depends upon the time of planting, as early or late planting of the rice plants may face a number of abiotic stresses. Timely transplanting of rice results in earlier harvest and allows timely planting of the next crops. One of the sound principles of SRI is age of seedlings, leading to greater root growth and better tillering potential. The age of seedlings exploit the initial vigour of the genotypes and provides congenial condition for better establishment. Transplanting of younger aged seedlings (10-day old) utilized phyllochronic potential to produce significantly higher grain yield (Shukla *et al*. 2014). Therefore, present field experiment was planned to study the effect of transplanting date and age of seedlings on growth, yield, soil fertility and quality of rice hybrids under SRI.

MATERIALS AND METHODS

A field experiment was conducted during rainy (*kharif*) seasons of 2012 and 2013 at Agricultural Research Farm, Banaras Hindu University, Varanasi (25^0 18' N, 88º03' E and 128.93 m above mean sea-level), Uttar Pradesh, India. Climate of the site is sub-tropical and sub-humid type with mean annual rainfall of 1 081.5 mm and a mean annual evaporation of 1 525 mm. The soil of the experimental field was sandy clay loam in texture (typic *Ustochrepts*) with pH 7.39. It was moderately fertile being low in organic carbon (0.39%) and available nitrogen (205.2 kg/ha), but medium in available phosphorus (25.3 kg/ha) and potassium (215.6 kg/ha). The experiment was laid out in split-split plot design assigning three date of transplanting (27 June, 7 July and 17 July) in main plot, two rice hybrids (PHB-71 and Pusa RH-10) in sub-plot and three age of seedlings (10, 14 and 18-day old) in sub-sub plot making 18 treatment combinations replicated thrice. Half dose of the total nitrogen (150 kg N/ha) through urea (37.5 kg N/ha) and vermicompost (37.5 kg N/ha) along with the full dose of phosphorus (75 kg P_2O_5/ha) through di-ammonium phosphate and potassium (75 kg K_2O/ha) through muriate of potash, were applied just before transplanting on puddled surface and incorporated into the top 15 cm soil. The remaining half amount of nitrogen (75 kg/ha) were applied through urea as top dressed in two equal installments at active tillering stage and 5-7 days before panicle initiation. Rice hybrids were sown in raised bed nursery as per treatment and single seedlings along with soil was transplanted by using index finger and thumb and gently planted at the marked intersection of 25 × 25 cm in puddled soil. Irrigation was applied depending on requirements. As cono-weeder being a part of SRI was used two times during 15-20 and 30-35 DAT. The other crop-management practices were followed as per system of rice intensification recommendations. The crop was harvested according to maturity as per treatments. The soil samples collected before transplanting and after harvesting of the crop during both the years were analysed for organic carbon by Walkley and Black's method, available N by alkaline permanganate method, P by Olsen's method, K by Flame-photometer after extraction with 1 *N* NH_4OAc (pH 7). The physical and chemical quality characteristics of kernels were determined for head rice recovery, kernel length, kernel breadth, length/breadth (L/B) ratio and linear kernel elongation ratio using an average of ten randomly selected kernels following the standard methods (Ghosh *et al*. 1971). Crop response to the treatments was measured in terms of various quantitative and qualitative indices. The LAI was measured by leaves of five plants taken from each penultimate rows and leaf area was recorded with a leaf-area meter (Systronics 211). The LAI was worked out as:

$$\text{Leaf-area index} = \text{Total leaf-area (cm}^2\text{)/Land area}$$

To calculate different quality parameters such as hulling and milling (%), 100 g sample of unhusked rice from each plot was subjected to dehusking in a SATAKE dehusker. The dehusked rice (brown rice) was weighed and percentage was determined by the following formula (Ghosh *et al*. 1971).

$$\text{Hulling percentage (\%)} = \frac{\text{Weight of brown rice (g)}}{\text{Weight of rough rice (g)}} \times 100$$

The brown rice obtained as above was milled to uniformly polished grain in 'Kett T-2 polisher' for 2 min and 30 sec. Time of the polisher was adjusted in such a way that per cent polishing is 5% (approx.). Total polished kernels (milled rice) were weighed and then milling percentage was calculated by the following formula (Ghosh *et al.* 1971):

$$\text{Milling percentage (\%)} = \frac{\text{Weight of milled rice (g)}}{\text{Weight of rough rice (g)}} \times 100$$

The polished kernels were then passed through rice grader having 5 mm grooves to separate whole grains from the broken ones in order to quantify the head rice recovery. If the grain was broken in two parts, then one-half of the grain was counted as one full grain. The process was repeated for three times. The percentage of the head rice recovery was calculated as per the following formula (Ghosh *et al*. 1971).

$$\text{Head rice recovery (\%)} = \frac{\text{Weight of whole polished rice (g)}}{\text{Weight of rough rice (g)}} \times 100$$

Protein content in grain was worked out by multiplying the nitrogen content in grain with the factor (6.25). Protein yield was determined by multiplying the protein content in grain with their respective yields. Kernel elongation ratio was obtained by division of length of cooked kernel to length of raw kernel.

RESULTS AND DISCUSSION

Growth parameters

Significant effect of transplanting date was observed on growth parameters of rice hybrids (Table 1). Early transplanting on 27 June significantly increased plant height, tillers/hill, leaf-area index and dry matter accumulation at 60 DAT over the later transplanting dates (7 and 17 July). It might be due to the fact that late planting had shorter growing period due to photoperiodic response and the June transplanting provided favourable environmental condition which enabled the plant to improve its growth and development as compared to the July transplanting (Chaudhary *et al*. 2011). A comparative study of the performance of rice hybrids exhibited that PHB71 recorded significantly higher plant height, tillers/hill, leaf-area index and dry matter accumulation. The differences in growth parameters between cultivars are mainly due to their genetic build up (Singh *et al.* 2013). Younger aged seedlings (10-day old) produced significantly higher plant height, tillers/hill, LAI and dry matter accumulation than older aged seedlings (14 and 18-day old). The transplanting of younger aged seedlings along with soil, keeping the roots intact, resulted in early adaptation of the seedling to soil and climatic condition thereby recording better growth parameters in agreement with Uphoff (2002). Mobasser *et al.* (2007) also observed that when seedling stay for a longer period of time in the nursery beds, primary tiller buds on the lower nodes of the main culm become degenerated leading to reduced growth parameters and tiller production.

Yield attributes and yield

Transplanting of rice on 27 June significantly produced 14.9, 11.1, 15.0, 29.3 and 7.2% more effective tillers/m^2, panicle length (cm), grains/panicle, weight/panicle (g) and test weight (g) with lowest number of unfilled spikelets/panicle (20) over 17 July transplanting (Table 1). Similarly, earlier transplanting on 27 June produced significantly the maximum grain yield (6.64 and 6.70 tonnes/ha) and straw yield (8.65 and 8.78 tonnes/ha during the two respective years) (Table 2). On the basis of pooled data, per cent increase in grain and straw yield by 27 June over 17 July planting was 19.9 and 15.2, respectively. It might be due to longer growing period of the crop for better development of parts to allocate greater accumulation of photosynthates in early planted crop which may result in the better development of growth and yield attributing characters (Singh *et al.* 2004). Hybrid rice planted on 7 July reduced the grain yield by 9.91 and 7.82% and straw yield by 6.87 and 6.27% as compared to 27 June planting during the respective years. Further, the reduction in grain and straw yield due to delayed planting on 17 July over 27 June was to the tune of 18.1 and

Table 1 Effect of date of transplanting and age of seedlings on growth parameters and yield attributes of rice hybrids under SRI (Pooled data of 2 years)

Treatment	Plant height at 60 DAT (cm)	No of tiller/hill at 60 DAT	LAI at 60 DAT	Dry matter accumulation at 60 DAT (g/hill)	Effective tillers/m^2 (No.)	Panicle length (cm)	Grains/panicle	Unfilled spikelets/panicle	Weight/panicle (g)	Test weight (g)
Date of transplanting (3)										
27 June	104.2	20.4	5.16	31.2	248.2	30.5	176	20	5.08	23.11
7 July	96.2	16.2	4.56	28.0	231.1	29.2	165	22	4.26	22.15
17 July	89.0	12.4	4.20	26.5	216.1	27.5	152	24	3.93	21.56
SEm+	1.19	0.07	0.11	0.23	3.09	0.23	2.78	0.74	0.12	0.20
CD (P=0.05)	4.67	0.27	0.45	0.89	12.13	0.89	10.91	2.92	0.46	0.78
Hybrids (2)										
PHB-71	104.8	17.6	4.91	29.5	236.4	30.1	188	21	4.62	22.67
Pusa-RH-10	88.2	15.1	4.38	27.6	227.1	28.0	141	23	4.23	21.88
SEm+	0.79	0.39	0.10	0.29	2.16	0.23	1.75	0.41	0.06	0.15
CD (P=0.05)	2.74	1.36	0.35	0.99	7.49	0.78	6.04	1.40	0.20	0.52
Age of seedlings (3)										
10-day	100.3	18.5	5.05	30.0	242.6	30.4	172	19	4.78	23.01
14-day	96.2	16.4	4.68	28.7	231.8	29.1	164	22	4.48	22.31
18-day	93.0	14.1	4.20	26.8	221.0	27.8	158	26	4.02	21.50
SEm+	1.10	0.48	0.12	0.27	2.40	0.16	1.76	0.46	0.05	0.17
CD (P=0.05)	3.22	1.39	0.36	0.78	7.02	0.46	5.14	1.35	0.16	0.49

DAT = Days after transplanting.

Table 2 Effect of date of transplanting and age of seedlings on yield (year-wise data) and harvest index of rice hybrids under SRI and their effect on soil fertility (Pooled data of 2 years)

Treatment	Grain yield (t/ha)			Straw yield (kg/ha)			Harvest index (%)	Soil *p*H (1 : 2.5 soil: water suspen-sion)	Soil EC (dS/m at 25°C)	Organic carbon (%)	Available nitrogen (kg/ha)	Available phos-phorus (kg/ha)	Available pota-ssium (kg/ha)	Total N removal (grain + straw) (kg/ha)	Total P removal (grain + straw (kg/ ha)	Total K removal (grain + straw) (kg/ ha)
	2012	2013	Pooled	2012	2013	Pooled										
Date of transplanting (3)																
27 June	6.64	6.70	6.67	8.65	8.78	8.71	43.2	7.38	0.14	0.44	179.7	17.5	206.8	136.5	30.0	164.3
7 July	5.98	6.17	6.08	8.05	8.23	8.14	42.6	7.39	0.13	0.43	181.1	19.4	210.0	123.7	26.7	149.1
17 July	5.43	5.69	5.56	7.45	7.68	7.56	42.2	7.39	0.15	0.41	185.9	20.1	211.9	112.6	23.9	135.1
SEm+	0.13	0.13	0.12	0.15	0.12	0.13	0.81	0.02	0.005	0.01	1.56	0.69	2.06	1.97	0.38	2.96
CD (P=0.05)	0.53	0.50	0.49	0.59	0.46	0.52	NS	NS	NS	NS	NS	NS	NS	7.74	1.49	11.62
Hybrids (2)																
PHB-71	6.89	7.11	7.00	8.83	9.07	8.95	43.9	7.38	0.14	0.44	180.2	18.1	206.9	141.0	30.5	166.7
Pusa-RH-10	5.15	5.26	5.20	7.27	7.39	7.33	41.5	7.39	0.14	0.41	184.3	19.9	212.2	107.6	23.2	132.3
SEm+	0.08	0.80	0.71	1.05	0.82	0.91	0.42	0.02	0.004	0.01	0.90	0.46	1.47	1.32	0.19	1.52
CD (P=0.05)	0.28	0.28	0.25	0.36	0.29	0.31	1.44	NS	NS	0.02	3.12	1.58	5.10	4.57	0.66	5.25
Age of Seedlings (3)																
10-day	6.44	6.52	6.48	8.31	8.52	8.42	43.4	7.36	0.14	0.45	178.1	18.1	204.7	132.5	29.4	158.4
14-day	6.00	6.18	6.09	8.07	8.18	8.13	42.7	7.41	0.15	0.42	182.2	19.1	209.6	124.0	26.7	149.2
18-day	5.62	5.86	5.74	7.76	7.99	7.87	41.9	7.39	0.14	0.40	186.4	19.9	214.5	116.3	24.5	140.8
SEm+	0.09	0.07	0.07	0.09	0.09	0.09	0.39	0.02	0.005	0.01	1.14	0.55	1.54	1.14	0.21	1.50
CD (P=0.05)	0.26	0.21	0.20	0.28	0.25	0.26	1.13	NS	NS	0.02	3.31	1.59	4.51	3.31	0.62	4.39
Initial value	7.39	0.18	0.39	205.2	25.30	215.6										

NS, Non-significant.

15.0% and 13.9 and 12.5% during the first and second years, respectively. The delayed transplanted crop was affected by decreased temperature during growing period more particular at anthesis and grain filling stages and reduced yield was mainly associated with the significant reduction in yield attributing characters. The harvest index was unaffected due to date of transplanting. Between hybrids, PHB-71 produced significantly 4.1, 7.4, 33.3, 9.2, 3.6, 34.5 and 22.1% more number of effective tillers/m^2, panicle length (cm), grains/panicle, panicle weight (g), test weight (g), grain and straw yield with minimum number of unfilled spikelets/panicle (20) along with maximum harvest index over Pusa RH-10. Genetic traits of hybrid PHB-71 allowed the rice plant to transform higher energy into the production of higher number of yield attributes and yield (Singh *et al*. 2013). The maximum harvest index (43.9%) was recorded with PHB-71 over Pusa RH-10. The higher harvest index was mainly due to higher grain yield of hybrid PHB-71 and enables to variation in partitioning of photosynthesis in grain is possible cause of a significant variation in harvest index (Ram *et al*. 2015). The transplanting of early aged seedlings (10-day old) produced significantly more effective tillers/m^2 (242.6), panicle length (30.4 cm), grains/panicle (172), lowest unfilled spikelets/panicle (19), weight/panicle (4.78 g), test weight (23.01 g) as compared to 14 and 18-day old seedlings. Juvenile aged seedlings also produced significantly higher grain yield which was 6.4 and 12.9% as well as straw yield by 3.6 and 6.9% higher over 14 and 18-day old seedlings, respectively, on pooled data basis. Harvest index was also recorded significantly higher with younger aged seedlings over older aged seedlings (14 and 18-day). The increased yield attributes and yield may be accounted due to concept of phyllochronic utilization followed by younger aged seedlings that resulted in improved growth parameters. Improvement in these growth parameters proved instrumental in increasing the yield parameters and yield with 10-day old seedlings (Singh *et al.* 2013 and Shukla *et al.* 2014).

Interaction effect

Transplanting of 10-day old seedlings of PHB-71 on 27 June recorded significantly higher effective tillers/m^2 over rest of the treatment combinations which was found at par with same date of transplanting and age of seedlings of Pusa RH-10 (Table 3). It could be due to the fact that younger seedling of rice transplanted on 27 June under SRI utilized phyllochronic potential and high temperature coupled with more solar radiation interception, i.e. more congenial thermo-periodism and photo-periodism were responsible to produce significantly higher number of effective tillers/hill. Grain yield of rice was also significantly influenced by interaction effect of date of transplanting, hybrids and age of seedlings. The maximum grain yield of rice was recorded with 10-day old seedlings of PHB-71 transplanted on 27 June but remained at par with 14-day old seedlings of PHB-71 transplanted on 27 June. Due to marked improvement in effective tillers/m^2, it proved instrumental in increasing grain yield under earlier planted crop. The higher grain yield in early planted crop might be due to optimum period available for growth and development resulting in more storage of photosynthates in grain as well as higher yield attributing characters observed under earlier planted crop than the later planted crop. These findings are confirmed by Mukesh *et al.* (2013) in basmati rice.

Table 3 Interaction effect of dates of transplanting, rice hybrids and age of seedlings on effective tillers/ m^2 and grain yield (tonnes/ha) under SRI (Pooled data of 2 years)

Treatment	PHB-71			Pusa RH-10			Mean
	10-day	14-day	18-day	10-day	14-day	18-day	
			Effective tillers/m^2				
27 June	268.8	257.9	236.8	256.4	240.3	229.1	248.2
07 July	251.5	231.1	220.9	236.0	228.6	218.5	231.1
17 July	224.3	220.7	215.6	218.6	212.5	205.0	216.1
Mean	248.2	236.6	224.4	237.0	227.1	217.5	
		SEm±			CD (P=0.05)		
D×H×A		5.89			17.19		
			Grain yield (t/ha)				
27 June	8.11	7.67	7.23	6.13	5.65	5.22	6.67
07 July	7.33	6.93	6.52	5.55	5.15	4.97	6.08
17 July	6.70	6.45	6.06	5.05	4.69	4.43	5.56
Mean	7.38	7.01	6.60	5.57	5.16	4.87	
		SEm±			CD (P=0.05)		
D×H×A		0.17			0.50		

D, Date of transplanting; H, Hybrids; A, Age of seedlings.

Quality parameters

Quality parameters, viz. hulling percentage, milling percentage, head rice recovery and kernel length (L) and breadth (B) before and after cooking and length/breadth ratio were analysed and found to be statistically on par due to different date of transplanting (Table 4). While, 27 June planting of hybrid rice recorded significant improvement in protein content in grains and kernel length before and after cooking as compared to 17 July planting. Similar results were also reported by Chaudhary *et al*. (2011). Regarding hybrids, PHB-71 showed significantly higher hulling (73.32), milling (65.57) percentage, head rice recovery (53.90%), protein content (7.73%) and kernel breadth before and after cooking (1.97 and 2.23 mm). Chaudhary *et al*. (2013) also concluded that the PHB-71 recorded highest hulling percentage and head rice recovery. However, the maximum kernel length before and after cooking (7.67 and 13.48) and L/B ratio before cooking (4.15) were recorded with Pusa RH-10. Length elongation ratio showed non-significant difference due to rice hybrids. This variation in different quality parameters might be due to genetic makeup and characteristics of the hybrids (Gautam *et al*. 2008). Head rice recovery, protein content, kernel length before and after cooking and length breadth ratio before cooking differed significantly due to age of seedlings. Younger aged seedlings

Table 4 Effect of date of transplanting and age of seedling on quality parameters of rice hybrids under SRI (Pooled data of 2 years)

Treatment	Hulling (%)	Milling (%)	Head rice recovery (%)	Protein content in grain (%)	Kernel length before cooking (cm)	Kernel length after cooking (cm)	Kernel breadth before cooking (mm)	Kernel breadth after cooking (mm)	Length elonga-tion ratio	Length breadth ratio before cooking
Date of transplanting (3)										
27 June	72.7	65.1	53.8	7.77	7.61	13.4	1.97	2.19	1.77	3.89
7 July	72.0	64.4	53.2	7.64	7.25	12.7	1.92	2.17	1.75	3.78
17 July	71.0	64.3	51.9	7.54	7.18	12.3	1.84	2.07	1.71	3.91
SEm+	0.86	0.59	0.50	0.04	0.13	0.22	0.06	0.03	0.04	0.077
CD (P=0.05)	NS	NS	NS	0.17	0.50	0.87	NS	NS	NS	NS
Hybrids (2)										
PHB-71	73.3	65.6	53.9	7.73	7.02	12.1	1.97	2.23	1.73	3.57
Pusa-RH-10	70.4	63.6	52.0	7.57	7.67	13.5	1.85	2.06	1.76	4.15
SEm+	0.74	0.44	0.32	0.03	0.06	0.18	0.03	0.02	0.02	0.038
CD (P=0.05)	2.56	1.53	1.11	0.10	0.22	0.63	0.10	0.08	NS	0.130
Age of seedlings (3)										
10-day	73.0	65.2	53.9	7.80	7.50	13.2	1.93	2.16	1.76	3.91
14-day	72.0	64.7	53.0	7.65	732	12.6	1.91	2.15	1.73	3.84
18-day	70.7	63.9	51.9	7.49	7.20	12.5	1.89	2.12	1.74	3.83
SEm+	0.78	0.45	0.33	0.05	0.05	0.11	0.01	0.01	0.02	0.026
CD (P=0.05)	NS	NS	0.98	0.14	0.15	0.32	NS	NS	NS	0.077

NS, Non-significant.

(10-day old) exhibited significantly the highest head rice recovery, protein content, kernel length before and after cooking and length breadth ratio before cooking over older aged seedlings (14 and 18-day old). However, 10 and 14-day old seedlings remained at par with each other in respect of head rice recovery and length breadth ratio before cooking (Pandey *et al.* 2013).

Soil fertility

Different date of transplanting did not show any significant effect on soil fertility, viz. soil *p*H, electrical conductivity, organic carbon, available nitrogen, phosphorus and potassium in soil after harvest of the rice (Table 2). Similar results have also been reported by Kumar *et al.* (2013). In between rice hybrids, available nitrogen, phosphorus and potassium status of soil remained significantly lowest with PHB-71 (180.2, 18.1 and 206.9 kg NPK/ha) as compared to Pusa RH-10 (184.3, 19.9 and 212.2 kg/ha). It was mainly due to more yield production by PHB-71 which led to more removal of nitrogen, phosphorus and potassium by crop from the soil, however, changes in soil pH and electrical conductivity were found non-significant due to rice hybrids, while significantly higher value of organic carbon content in soil was recorded with PHB-71 over Pusa RH-10. It might be due to the fact that PHB-71 have well developed root pattern (Manjunath *et al*. 2012) as compared to Pusa RH-10 therefore add more root biomass that caused increased in organic carbon content in soil. Further, among the age of seedlings, 18-day old seedlings recorded the maximum available nitrogen, phosphorus and potassium status in soil. This might be due to older aged seedlings removing less nutrient from soil as compared to younger aged seedlings. The result supported the findings of Singh *et al.* (2013). However, 10-day old seedlings recorded the minimum value of available nitrogen, phosphorus and potassium in soil after harvest. Different age of seedlings showed non-significant variation on soil pH and electrical conductivity. Organic carbon is the store house of nutrient which is considered as notable soil health parameter. Organic carbon content in soil after harvest of rice was higher (0.45%) under the planting of younger aged of seedlings (10-day) as compared to older aged of seedlings (14 and 18-day). The increase in organic carbon content in the younger aged seedlings was attributed to better root growth might be due to long period available for their growth and development, resulting in the higher production of biomass. The subsequent decomposition of root biomass might have resulted in the enhanced carbon content in soil. These results are in agreement with the findings of Nayak *et al*. (2012).

Thus, it can be concluded that transplanting of 10-day old seedlings of rice hybrid PHB-71 on 27 June under system of rice intensification proved optimum for producing higher growth, yield parameters, yield, quality parameters and improving organic carbon content in soil of rice under agro-climatic condition of Eastern Uttar Pradesh.

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